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XRD and FTIR of Ascorbic Acid and Monosodium Glutamate Food Additives

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ABSTRACT

There are a numerous count of food additives consumed by human every day, in this research paper we focused on XRD and FTIR physical characterization of ascorbic acid and mono sodium glutamate as two of the most common used food additives, The structural analysis of ascorbic acid reveals that it has a monoclinic crystal structure with particle size in the nanoscale (41.496 ± 12.96 nm). While the structural analysis for monosodium glutamate reveals that it has a polycrystalline nature with particle size in the Nano scale (40.13 ± 12.6 nm).

1.Introduction

A food additive is any substance added to food at any stage to improve its keeping quality, taste, color, texture, alkalinity or acidity, or consistency or to serve any other technological function in relation to food. There are thousands of food additives used as antioxidants, flavorings and coloring agents, preservatives, sweeteners, thickeners, and many others [1].

According to European Community (EC) legislation food additives are defined as 'any substance not normally consumed as a food in itself, food additives could be natural or synthetic and assigned as E numbers, also food additives to be authorized should satisfying three conditions :
(i) There is a technological demand for their use

(ii) Consumers are not misled

(iii) Additives are not hazardous to consumers' health

Vitamin C $C_6H_8O_6$ (ascorbic acid) is one of the most essential vitamins for human body, it's an organic compound, water soluble vitamin which act as a very strong antioxidant agent, ascorbic acid can stop free radicals activity and it's destructive effect, ascorbic acid also is very important for other vitamins maintenance like vitamin B1,B12,E and vitamin A, it's also important for wound healing [2], collagen synthesis, and normal blood hemostasis [3]. Mono sodium glutamate (MSG) is a wildly used flavor enhancer which is being used for 100 years roughly [4]. MSG is derived from L-glutamic acid which is non-essential amino acid that our bodies can produce it [5]. It's also known as E621 according to European legislation, MSG is a crystalline powder which dissolves easily in water [5].
The current study has conducted a comparison between two of the most common food additives utilized by human every day, which are ascorbic acid and monosodium glutamate, to figure out the safety of use and to estimate their toxicity.

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2.Material and Methods

2.1 Chemical and Reagent

The following chemicals were used in this study, all these chemicals were used without additional purification ascorbic acid and monosodium glutamate were purchased from Loba chemie – india.

2.2 Physicochemical characterization

X-ray diffraction (XRD) measurements were performed using X'Pert PRO-PAN analytical diffractometer with Cu-Kα radiation (λ= 1.54056 A˚) at 40 kV and 30mA to examine the polycrystalline nature of MSG. The size of the crystallites responsible for the Bragg reflection was determined using the well-known Scherer relationship [6]

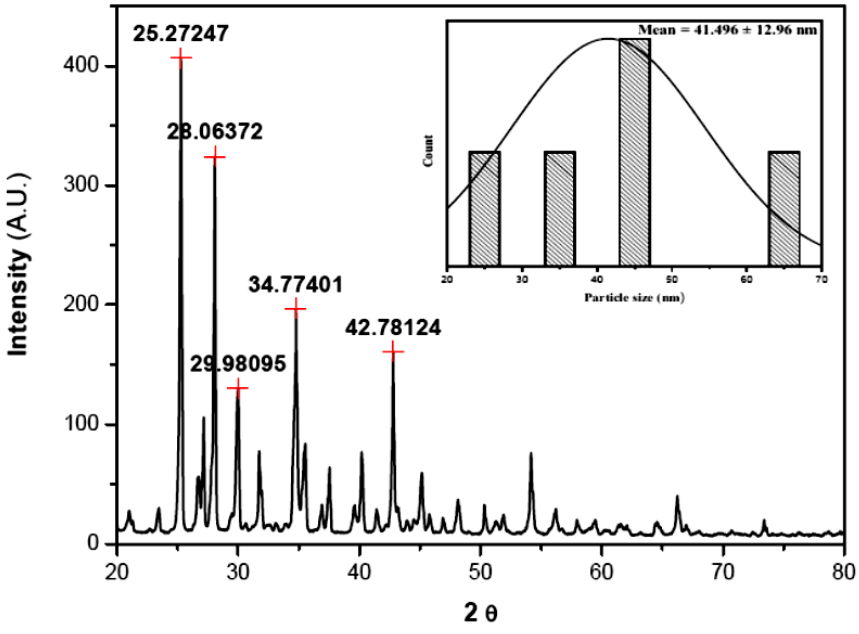
$$D = \frac{0.9\lambda}{\beta \cos\theta} (1)$$

where D is the crystallite diameter in A˚, *K* is the shape constant (~ 0.9), λ is the wavelength in A˚, θ is the Bragg angle in degrees and β is the observed peak width at half-maximum height in rad.

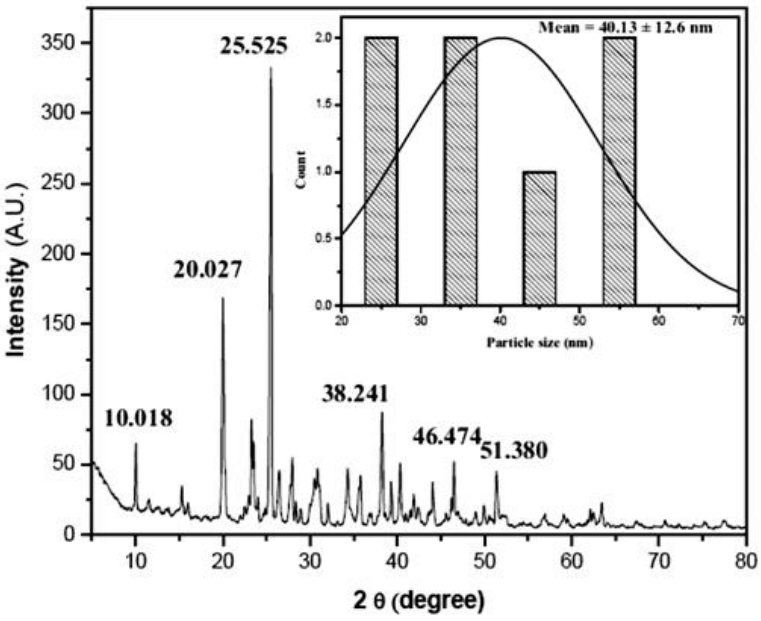
The functional groups were measured using FTIR-4100 type A in the 349.053 -7800.65 cm^{-1} range, with a resolution of 4 cm^{-1} at room temperature.

3. Results and discussion

3.1 X-ray diffraction (XRD)



1. **Fig. 1**: XRD pattern of ascorbic acid

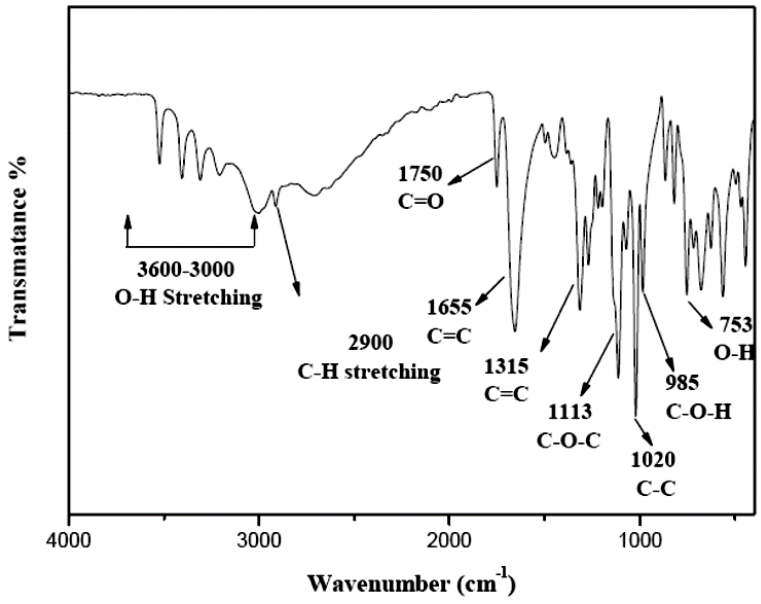


2. **Figure 2** XRD pattern of MSG

The XRD patterns of our food additives was presented in figure 1 and 2. The diffraction pattern reflect the polycrystalline nature of ascorbic acid with a characteristic peak at 2θ (25.27, 28.06, 29.98, 34.77 and 42.78), which in a good agreement with the reported XRD in previous studies [12]. According to literatures ascorbic acid $C_6H_8O_6$ (M = 176.12 g.mol^{-1}) have a monoclinic crystal structure with a non-centrosymmetric space group *P2*. In addition it has a unit cell volume 688.712 A^{o3} and lattice parameters a= 17.299 A°, b= 6.262 A°, c= 6.411 A° and β= 102.18° [13].

The calculated lattice parameters for our sample was a= 17.289 A°, b= 6.88 A° and c= 6.486 A°, which is confirm the purity of our sample. The calculated crystal size of ascorbic acid was 41.496 ± 12.96 nm, which reflect the nano nature of ascorbic acid, in case of MSG the diffraction pattern reflects the polycrystalline nature of MSG with a characteristic peak at 2θ (10.018, 20.027, 25.525, 38.241, 46.474 and 51.380), which in a good agreement with the reported XRD in previous studies [14].The calculated crystal size of MSG from Scherer equation was 40.13 ± 12.6 nm, which reflect the Nano nature of MSG. This smaller size may be responsible for the cytotoxic effect of MSG as it facilitates its uptake through cells.

3.2 Fourier Transformation IR spectroscopy (FTIR)



3. **Fig. 1**: FT-IR analysis for ascorbic acid to pinpoint functional groups

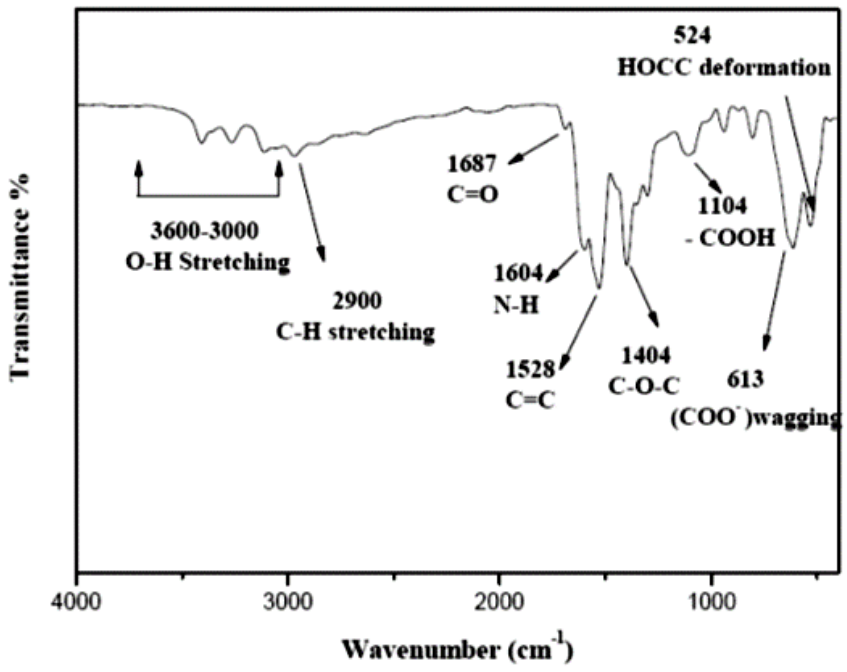


Figure 4 FT-IR analysis for MSG to pinpoint functional groups

IR spectra of ascorbic acid is presented in figure (3) Different functional groups can be observed in the FTIR spectrum the peaks of ascorbic acid. The band observed in the range 3000–3600 cm^{-1} correspond to the different hydroxyl groups due to presence of moisture in sample. The stretching vibration of C-C double bond and the peak of enol-hydroxyl which were observed at 1665 cm^{-1} and 1315 cm^{-1} respectively, Another characteristic peak of ascorbic acid that appears in the spectrum at 1271 cm^{-1} can be assigned to O-H in plane bending bond [15, 16]. On the other hand FTIR spectra of MSG were characterized by several vibrational bands as shown in figure (2). The vibrational bands observed in the range 3000 ~ 3600 cm^{-1} were corresponding to O-H stretching vibration in the molecule, which is formed due to the presence of hydrogen bonds in the molecule. The vibrational band observed at 2900 cm^{-1} due to C-H stretching vibration, while C=O stretching vibration appeared at 1687 cm^{-1}. The band observed at 1604 cm^{-1} is due to N-H stretching vibration. The band at 1528 cm^{-1} and 1404 cm^{-1} are corresponding to C=C and –COO stretching vibration, respectively. The absorption bands at 1104, 613 and 524 cm^{-1} are attributed to the stretching vibration of -COOH, wagging vibration of (COO)- and the deformation of HOCC, respectively [17].

4.Conclusion

This study has made a physical characterization comparison between two of most common food additives ascorbic acid and monosodium glutamate respectively, to pinpoint the functional groups in each food additive using FTIR and to calculate particle size of each one using XRD.
Our results showed a Nano-sized particles of each compounds which may affect their diffusion on human cells leading to cytotoxicity, we recommend a critical focusing on studying the safety of food additives in future food science research.

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